073206T4CEN

CIVIL ENGINEERING LEVEL 6

CON/OS/CET/CC/03/6/A

PERFORM STRUCTURAL DESIGN AND ANALYSIS

July/August 2024

TVET CURRICULUM DEVELOPMENT, ASSESSMENT AND CERTIFICATION COUNCIL (TVET CDACC)

WRITTEN ASSESSMENT

TIME: 3 HOURS

INSTRUCTIONS TO CANDIDATE

1. This paper has two sections A and B.
2. Answer ALL the questions as guided in each section.
3. You are provided with a separate answer booklet.
4. Marks for each question are indicated in the brackets.
5. Do not write on the question paper.

This Paper Consists of SEVEN (7) Printed Pages.

Candidates should check the question paper to ascertain that all pages are printed as indicated and that no pages are missing

SECTION A (40 MARKS).

Answer ALL the questions

1. Structural elements are load bearing parts of a structure. Outline any THREE elements. (3 Marks)
2. Beams are flexural members that support loadings on a structure. Use a well labeled diagram sketch structural drawings of the following beams.
   a. Rectangular beam; (2 Marks)
   b. T beam. (2 Marks)
3. A civil engineer designs structures to prevent failure by considering various constraints associated with structural members. Describe TWO constraints. (2 Marks)
4. When designing structures, engineers pay close attention to the different types of loads that the structure will be subjected to. Name THREE types of loads. (3 Marks)
5. Analyze the beam in the figure 1 and determine its support reactions. Draw Shear Force and Bending Moment diagrams. (6 Marks)

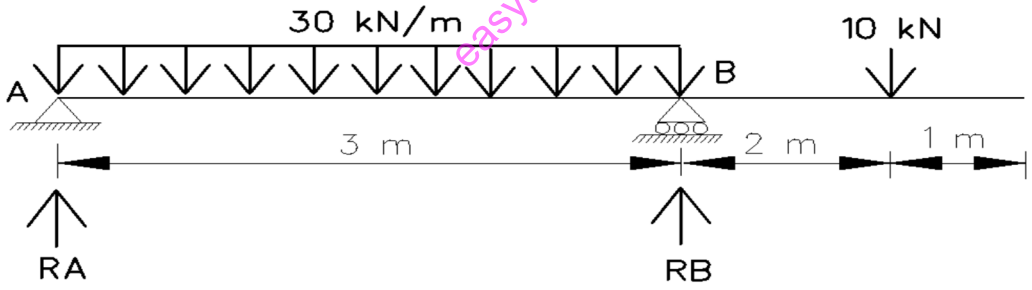

Fig 1

6. When analyzing a structure for slope and deflection, it is important to establish the behavior of structural members when subjected to loading. List TWO assumptions made when analyzing slope and deflection. (4 Marks)
7. Differentiate between determinate and indeterminate structures (4 Marks)
8. When designing a structure, different criterions are used. Outline THREE criterions. (3 Marks)
9. Figure 2 shows a cantilever beam subjected to a point load. Analyze the beam for bending moment and draw shear force and bending moment diagrams. (5 Marks)

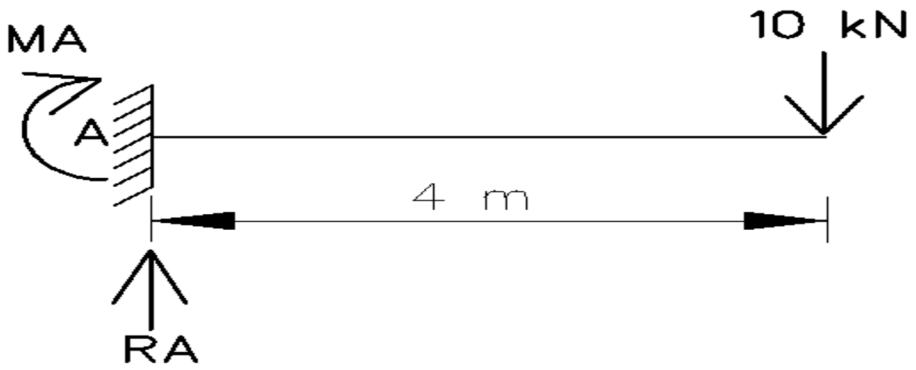

Fig 2

10. Foundations are structural elements that transmit the load of the superstructure to the ground. If not well designed, they can fail, leading to the failure of the entire structure. Discuss THREE modes of failure in foundations. (6 Marks)

SECTION B (60 MARKS)

Answer THREE questions

11. A simply supported beam is subjected to a load varying uniformly from w at the center to zero at the supports. Derive general expressions for slope and deflection, and find the slope at the supports and the maximum deflection. EI is constant. (20 Marks)
12. Masonry students were contracted to construct a pump house using masonry blocks. The effective span of the house was 6m and 5m. Design a flat concrete roof for the structure using the following information;

    i. Thickness of slab -125mm.
    ii. Strength of concrete - 35N/mm2.
    iii. Strength of steel - 460N/mm2.
    iv. Unit weight of concrete - 24KN/m3.
    v. Imposed load - 2KN/m2. (20 Marks)

13. A renovation of a structural building was done and the concrete continuous beam was replaced with universal beam. Loading on each span were determined and presented on figure 3. Using three moment theorem, determine the moments and shear force in each support. (20 Marks)

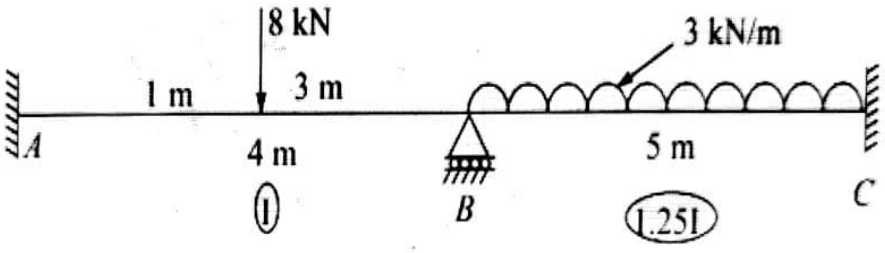

Fig 3

14. Analyze the retaining wall shown in figure 4 for overturning, sliding and bearing of soil given the factor of safety is 1.5, given that, $\Phi=30^0$, unit weight of soil =18kN/m^3, coefficient of friction =0.6, allowable soil bearing capacity= 180kN/m^3 and unit weight of soil=24kN/M^3.

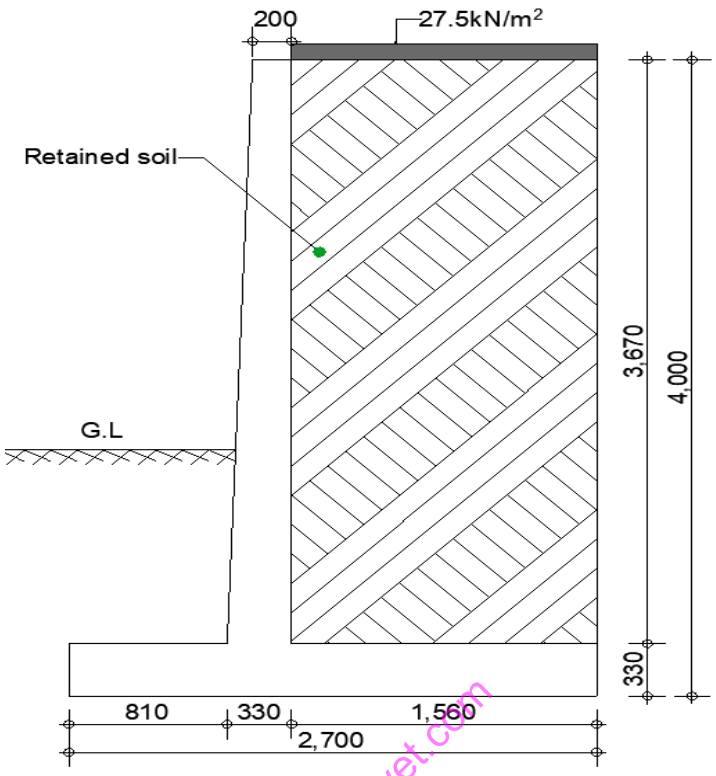

Fig 4

(20 Marks)

DESIGN TABLES TO BRITISH STANDARD DESIGN CODE

Bar size (mm)	Number of bars									
	1	2	3	4	5	6	7	8	9	10
6	28.3	56.6	84.9	113	142	170	198	226	255	283
8	50.3	101	151	201	252	302	352	402	453	503
10	78.5	157	236	314	393	471	550	628	707	785
12	113	226	339	452	566	679	792	905	1020	1130
16	201	402	603	804	1010	1210	1410	1610	1810	2010
20	314	628	943	1260	1570	1890	2200	2510	2830	3140
25	491	982	1470	1960	2450	2950	3440	3930	4420	4910
32	804	1610	2410	3220	4020	4830	5630	6430	7240	8040
40	1260	2510	3770	5030	6280	7540	8800	10100	11300	12600

Class	Cement combination type[1]	Strength class, max. w/c ratio, min. cement or combination content (kg/m^3) or equivalent designated concrete							
		Nominal cover to reinforcement							
		15+Δc	20+Δc	25+Δc	30+Δc	35+Δc	40+Δc	45+Δc	50+Δc
1. No risk of corrosion									
X0	All	Not recommended for reinforced concrete structures							
2. Corrosion induced by carbonation									
XC1	All	C20/25, 0.70, 240	→ use the same grade of concrete						
XC2	All	–	–	C25/30, 0.65, 260	→				
XC3/ XC4	All except IVB	–	C40/50, 0.45, 340	C30/37, 0.55, 300	C28/35, 0.60, 280	C25/30, 0.65, 260	→		
3. Corrosion induced by chlorides									
XD1	All	–	–	C40/50, 0.45, 360	C32/40, 0.55, 320	C28/35, 0.60, 300	→		
XD2	CEM I, IIA, IIB–S, SRPC	–	–	–	C40/50, 0.40, 380	C32/40, 0.50, 340	C28/35, 0.55, 320	→	
	IIB–V, IIIA	–	–	–	C35/45, 0.40, 380	C28/35, 0.50, 340	C25/30, 0.55, 320	→	
	IIIB–V, IVB	–	–	–	C32/40, 0.40, 380	C25/30, 0.50, 340	C20/25, 0.55, 320	→	

Values of υ (N/mm²)	*Area of shear reinforcement to be provided*
$\upsilon < 0.5\upsilon_c$ throughout the beam	No links required but normal practice to provide nominal links in members of structural importance
$0.5\upsilon_c < \upsilon < (\upsilon_c + 0.4)$	Nominal (or minimum) links for whole length of beam $A_{sv} \geq \frac{0.4bs_v}{0.87f_{yv}}$
$(\upsilon_c + 0.4) < \upsilon < 0.8\sqrt{f_{cu}}$ or 5 N/mm²	Design links $A_{sv} \geq \frac{bs_v(\upsilon - \upsilon_c)}{0.87f_{yv}}$

Diameter (mm)	*Spacing of links* (mm)										
	85	*90*	*100*	*125*	*150*	*175*	*200*	*225*	*250*	*275*	*300*
8	1.183	1.118	1.006	0.805	0.671	0.575	0.503	0.447	0.402	0.366	0.335
10	1.847	1.744	1.57	1.256	1.047	0.897	0.785	0.698	0.628	0.571	0.523
12	2.659	2.511	2.26	1.808	1.507	1.291	1.13	1.004	0.904	0.822	0.753
16	4.729	4.467	4.02	3.216	2.68	2.297	2.01	1.787	1.608	1.462	1.34

$\frac{100A_s}{bd}$	*Effective depth (d) mm*							
	125	*150*	*175*	*200*	*225*	*250*	*300*	*≥ 400*
≤ 0.15	0.45	0.43	0.41	0.40	0.39	0.38	0.36	0.34
0.25	0.53	0.51	0.49	0.47	0.46	0.45	0.43	0.40
0.50	0.57	0.64	0.62	0.60	0.58	0.56	0.54	0.50
0.75	0.77	0.73	0.71	0.68	0.66	0.65	0.62	0.57
1.00	0.84	0.81	0.78	0.75	0.73	0.71	0.68	0.63
1.50	0.97	0.92	0.89	0.86	0.83	0.81	0.78	0.72
2.00	1.06	1.02	0.98	0.95	0.92	0.89	0.86	0.80
≥ 3.00	1.22	1.16	1.12	1.08	1.05	1.02	0.98	0.91

Service stress	M/bd^2								
	0.50	*0.75*	*1.00*	*1.50*	*2.00*	*3.00*	*4.00*	*5.00*	*6.00*
100	2.00	2.00	2.00	1.86	1.63	1.36	1.19	1.08	1.01
150	2.00	2.00	1.98	1.69	1.49	1.25	1.11	1.01	0.94
(f_y = 250) 167	2.00	2.00	1.91	1.63	1.44	1.21	1.08	0.99	0.92
200	2.00	1.95	1.76	1.51	1.35	1.14	1.02	0.94	0.88
250	1.90	1.70	1.55	1.34	1.20	1.04	0.94	0.87	0.82
300	1.60	1.44	1.33	1.16	1.06	0.93	0.85	0.80	0.76
(f_y = 500) 323	1.41	1.28	1.18	1.05	0.96	0.86	0.79	0.75	0.72

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